Technical Note 403

Helium Resources of the United States-1997

By B.D. Gage and D.L. Driskill

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U.S. Department of the Interior

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Unit of Measure Abbreviation Used in Report

Bcf	billion cubic feet
Btu	British thermal unit
F	degree Fahrenheit
MMcf	million cubic feet
%	percent
psia	pounds per square inch, absolute
Tcf	trillion cubic feet

Helium Resources of the United States - 1997

By Brent D. Gage[1] and David L. Driskill[2]

Abstract

The identified helium resources of the United States are estimated at 589 Bcf, as of December 31, 1996. This includes 268 Bcf of demonstrated reserves, 102 Bcf of demonstrated marginal reserves, and 30 Bcf of demonstrated subeconomic resources. The identified resources also include 157 Bcf of helium in inferred reserves and inferred marginal reserves and 32 Bcf in inferred subeconomic resources. The demonstrated helium resources contained on Federal lands are approximately 165 Bcf, including 31 Bcf in underground storage in the Cliffside Gasfield near Amarillo, Texas. In addition to the identified helium resources, undiscovered helium resources in the United States are estimated at a most likely volume of 109 Bcf, with a maximum volume of 258 Bcf and a minimum volume of 44 Bcf. Also reported are 52 Bcf of helium in nonconventional and low helium content natural gases.

Current extraction of helium in the United States occurs mostly from natural gases produced from the Hugoton gas area in Kansas, Oklahoma, and Texas, and the Riley Ridge area in southwestern Wyoming. Helium extracted from natural gas in the United States in 1996 was approximately 3.8 Bcf. The addition of crude helium plants in the midcontinent area since the last report has increased the volume of helium available for storage by private industry. However, the volume of helium produced with the natural gas in the Hugoton gas area continues to decline. The current trend is storage by private industry at the Cliffside Gasfield, and the shortfall of helium supply will reverse this trend to withdrawal of helium. If the current trends continue, a shortage of helium supply could occur in about 5 to10 years.

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Introduction

The identified helium resources of the United States are estimated at 589 Bcf[3]. This includes both demonstrated and inferred helium contained in proved, probable, and possible natural gas resources[4]. It also includes helium previously separated from natural gases and stored at the Cliffside Gasfield in Potter County, Texas. The helium contained in other occurrences of natural gas in the United States is estimated at 52 Bcf; this includes helium in nonconventional gas reserves and low helium content natural gas. The undiscovered helium resources in the United States are estimated at a most likely value of 109 Bcf. This results in a total helium resource base of 750 Bcf.

This publication is the 11th in a series of reports on the helium resources of the Nation. The first of these reports gave information on helium resources as of January 1, 1973(1)[5]. The reports have been published approximately every 2 years with the last circular reporting information as of December 31, 1992(2-10). It has been 4 years since the update to this publication due to uncertainty of the structure of the final organization of Helium Operations, as pertaining to the Helium Privatization Act of 1996. This has been addressed and a return to a biennial reporting schedule is anticipated.

The Bureau has been estimating the helium resources of the Nation for about 50 years in connection with a search for helium occurrences that has been conducted for over 80 years. These activities are carried on: (1) to ensure a continuing supply of helium to fill essential Federal needs, (2) to provide information to the Secretary of the Interior so that helium resources reserved to the United States on Federal land can be properly managed, and (3) to provide the public with information on a limited natural resource that is being depleted.

The Mineral Lands Leasing Act of 1920 reserves to the United States all helium found on Federal lands leased under the provisions of that Act. The responsibility for ensuring a supply of helium to meet essential Federal needs was assigned to the Secretary of the Interior by the Helium Act of March 31, 1925. This was followed by the Helium Act Amendments of 1960. The latest legislation pertaining to helium is the Helium Privatization Act of 1996. The helium resource estimates and supply/demand forecasts presented in this report are realistic for the short term; however, as in all long-term forecasts, less reliance should be placed on the estimate toward the end of the forecast.

The estimate of the total helium resource base of 750 Bcf compares with 772 Bcf estimated as of December 31, 1992. The decrease is due to changes in estimates of natural gas resources by the Potential Gas Committee (PGC)(11), continued refinement in helium content averages by the Bureau, and natural gas production during the last 4 years. The identified resources are classified based on degree of geological assurance of occurrence. This classification results in the categories termed measured, indicated, and inferred resources. See the Glossary for definitions of these terms and their relationship to the oil and gas industry terms of proved, probable, and possible. Measured resources, including storage, are 232 Bcf; indicated resources are 168 Bcf, and inferred resources are 189 Bcf.

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[3] All values in this report, unless otherwise stated, are at 14.65 psia and 60°F as of December 31, 1996.

[4] See Glossary for definitions of resource terms.

[5] The numbers in parentheses refer to items in the list of references near the end of this report.

The identified helium resources can be subdivided into three categories (Figure 1): (1) reserves containing 361 Bcf, which includes helium in underground storage; (2) marginal reserves containing 166 Bcf; and (3) subeconomic resources containing 62 Bcf. The helium resource base also includes approximately 52 Bcf of helium in other natural gas occurrences. These natural gas occurrences include coal-bed methane and natural gases with very low helium contents, generally less than 0.05%. The undiscovered helium resources comprise the remainder of the helium resource base, and the estimate, 109 Bcf, is based on the most likely speculative gas resource values provided by the PGC. The minimum value for the undiscovered resources is 44 Bcf and the maximum value is 258 Bcf. The definitions for the above helium and natural gas resource terms are found in the Glossary. The definitions and uses of the terms in this circular follow the general guidelines established by the United States Geological Survey and the Bureau as published in USGS Bulletin 1450-A, *Principles of the Mineral Resource Classification System of the United States Bureau of Mines and the United States Geological Survey, 1976* and later revised in Geological Circular 831, 1980.

This report categorizes the resources on an economic basis. The helium content of the gases is an economic consideration because the extraction costs generally decrease as helium content increases. However, other factors that affect the economic potential of helium deposits are also considered and included in classifying the helium resources. These factors include the average daily rate of processed gas, hydrocarbon recovery, life of the reserves, size of reserves, and proximity to the Government's helium storage system.

IDENTIFIED RESOURCES [1]

	Demonstrated			Inferred
	Measured		Indicated	
Reserves	Storage 35	182	51	93
Marginal Reserves	5		97	64
Sub-Economic Resources	10		20	32

Undiscovered Resources		
Probability Range		
Minimum	Most Likely	Maximum
44	109	258

Other Occurrences
Includes nonconventional and low-grade materials
52

[1] A part of reserves or any resource category may be restricted from extraction by laws or regulations.

Figure 1. Identified and undiscovered helium resources in the United States (billion cubic feet at 14.65 psia and 60°F). Modified from "Principles of a Resource/Reserve Classification of Minerals" (Geological Survey Circular 831, 1980).

Identified Helium Resources

Helium occurs as a constituent of natural gas, which is presently the only economical source, and helium is also present in the atmosphere. For this report, helium in the atmosphere is not considered as part of the helium resource base. The natural gas in which helium is found may be normal fuel gas; naturally occurring, low-Btu gas; or nonconventional gas resources such as coal-bed methane and carbon dioxide gas. The helium content of the natural gas resources are derived from Bureau records of helium analyses of natural gas samples, which are a part of the Bureau resource data base. The analyses of natural gas and limited evaluations of helium resources started in 1917. Over 19,800 natural gas samples from wells and pipelines in the United States and other countries have been analyzed through 1995, and 15,891 of these analyses have been documented in 41 Bureau publications. These publications are listed in the bibliography of this report.

Helium in Storage

In 1961, the Government contracted to purchase helium from five extraction plants built by four private companies adjacent to large natural gas transmission pipelines. The gas, principally from the West Panhandle and Hugoton gasfields in the Oklahoma and Texas Panhandles and in southwestern Kansas, was being produced for fuel. As the gas was burned, the helium was released to the atmosphere and wasted. Using private funds, these companies constructed plants to extract crude helium for sale to the Government. The helium was delivered into a Government-owned pipeline that connected all plants with the Bush Dome in the Cliffside Gasfield near Amarillo, Texas. Further information concerning the Government's helium purchases can be found in the first report of this series (1) and the section in this report on the history and uses of helium.

As of December 31, 1996, the helium stored in Bush Dome totals 34.6 Bcf. Of this total, 30.5 Bcf was accepted by the Government from the conservation plants under contract and was excess to Federal market demands. The other 4.1 Bcf is stored by the Government for private companies under separate storage contracts.

Bush Dome was the source of helium-bearing natural gas that was produced for helium extraction at the Government's Amarillo Helium Plant from 1929 until the plant ceased helium extraction operations in April 1970. About 109 Bcf of natural gas has been produced from the field and there are about 201 Bcf of remaining recoverable gas reserves. The natural gas averages about 1.86% contained helium; therefore, the remaining native helium reserves are about 3.7 Bcf. Since the Amarillo Helium Plant ceased helium extraction operations, natural gas has been produced from Bush Dome for fuel gas and helium extraction at the Government's Exell Helium Plant operations north of Amarillo, Texas. The Helium Privatization Act of 1996 mandated the cessation of the operation of the Exell Helium Plant, with private industry supplying Federal agencies using In-Kind Crude Helium Sales (IKCHS) contracts. Helium contained in the remaining native gas is included with the helium in proved natural gas reserves (measured helium reserves).

Other Measured Helium Resources

Measured helium in proved natural gas reserves is estimated at 197 Bcf, not including storage and other occurrences of helium. The measured helium is subdivided into reserves, marginal reserves, and subeconomic resources. Presently, all measured reserves are in helium-rich natural gas. The marginal reserves and subeconomic helium resources are contained in both helium-rich and helium-lean natural gas. All gasfields known to contain

at least 0.05% helium have been individually evaluated and are part of the demonstrated helium resources. Fields containing less than 0.05% helium are not individually evaluated. The helium resources in these fields are estimated by using average helium contents of natural gas from representative fields and basins and applying those values to the Department of Energy/Energy Information Administration (DOE/EIA) reserve estimate (12). These helium resources, although they are contained in proved natural gas reserves, are reported as other occurrences of helium.

Measured Helium Reserves

The measured helium reserves are estimated at 182 Bcf, excluding storage. These reserves are located in 12 gas-producing areas in 8 states. The reserves by state and area are listed in Table 1. The locations are shown in Figure 2.

Since 1950, the Bureau has been making estimates of the helium resources of the Nation, although for several years the estimates included only the fields that contained major deposits of at least 0.30% helium. These fields were the Hugoton in southwestern Kansas and the Oklahoma and Texas Panhandles, the West Panhandle in Texas, the Greenwood in Kansas, the Keyes in Oklahoma, and the Cliffside Field in Texas. Even today these fields are estimated to contain approximately 26%, or 47 Bcf, of the measured helium reserves. The natural gas from all these fields is being produced for fuel, and the helium that is not extracted is lost as the natural gas is burned. Bush Dome in Cliffside Gasfield is produced for redelivery of private helium stored under contract and to meet the Federal Government's helium needs. Currently, Federal

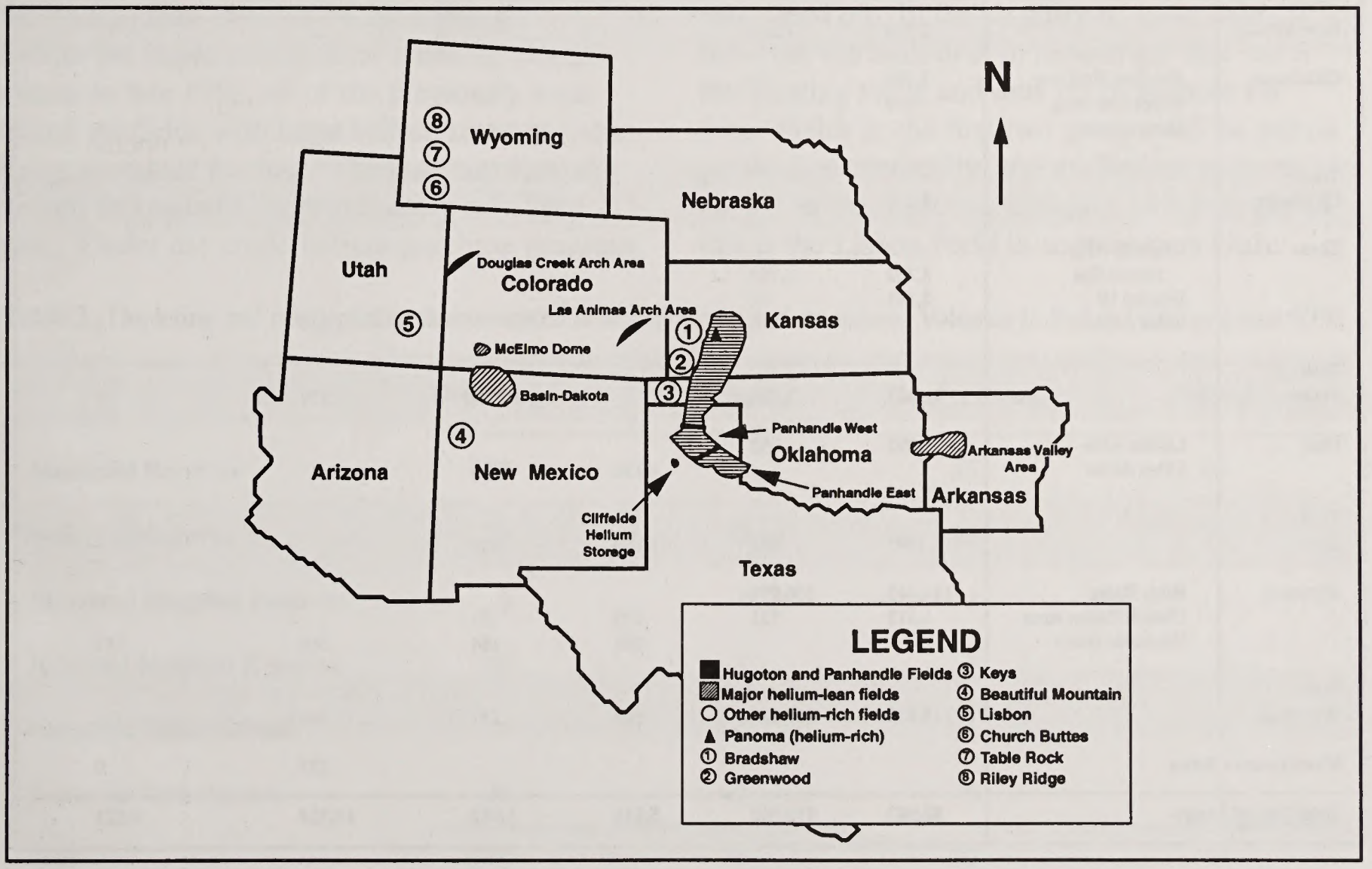

Figure 2. Location of major helium-bearing gasfields.

Table 1. Measured helium reserves. Volumes are in MMcf as of December 31, 1996.

State	Area	Helium Reserves	Federally Owned	Marginal Helium Reserves	Federally Owned	Subeconomic Helium Resources	Federally Owned
Arizona	Apache County	2,564	0				
Arkansas	Arkansas Valley			1,674	127		
Colorado	Baca County			164	8		
	Douglas Crk Arch			480	462		
	Paradox Basin					5,331	4,110
	Miscellaneous			308	219	64	64
	Las Animas Arch	1872	0				
Total Colorado		1872	0	952	689	5,395	4,174
Kansas	Hugoton	41,856	1,647				
	Other Areas			483	0	612	28
Total Kansas		41,856	1,647	483	0	612	28
Montana	Rudyard/Utopia			189	0		
	Other Areas					1,051	160
New Mexico	Chaves County	1,941	1,223				
	Northwest NM	855	24				
Total New Mexico		2,796	1,247				
Oklahoma	Guymon Hugoton	3,199	19				
	Keyes Gas Area	619	7				
	Other Areas					1,196	3
Total Oklahoma		3,818	26			1,196	3
Texas	Cliffside Area						
	Native Gas	3,762	3,762				
	District 10	8,345	22				
	Other Areas					1,279	5
Total Texas		12,107	3,784			1,279	5
Utah	Lisbon Area	1,095	953				
	Other Areas			1,150	929		
Total Utah		1095	953	1,150	929		
Wyoming	Riley Ridge	114,443	106,974				
	Church Buttes Area	1,412	721	175	53		
	Washakie Basin			493	184	368	151
Total Wyoming		115,855	107,695	668	237	368	151
Miscellaneous States						323	0
Total United States		181,963	**115,352**	**5,116**	**1,982**	**10,224**	**4,521**

Government agencies receive their helium through private suppliers. The suppliers must purchase, from the Government's helium reserve, an amount of helium equal to the amount sold to Government agencies, using an IKCHS contract.

As the helium resources evaluation program in the United States progressed, more comprehensive data were collected and the estimates were improved. In 1961, a major improvement in the program took place when, for the first time, helium reserves were estimated for all fields in the United States from which samples containing more than 0.30% helium had been analyzed in connection with the gas-sampling program. Available data for many of these smaller fields were limited for the first evaluation efforts; however, over the intervening years, data has been collected from all known, available sources. This has resulted in a comprehensive assessment of the total helium reserves of the country. Before the implementation of crude helium purchases in late 1962, all of the previously mentioned gasfields with large helium reserves were being produced for fuel. The resultant loss of helium amounted to approximately 8 Bcf per year. Under the crude helium purchase program, approximately 3.5 Bcf of helium, that otherwise would have been wasted, was saved annually from 1963 through November 12, 1973, when the Government purchase of helium from the private conservation plants ceased.

Some of the gasfields that contain measured reserves of helium are not being produced, and the helium is not being wasted. These are classified as nondepleting helium reserves. There are 38 fields in 7 states that are nondepleting. These nondepleting fields contain both reserves and marginal reserves of helium. Table 2 lists the nondepleting and depleting resources by category.

There are various reasons why these fields are not being produced. Some are located in remote areas where pipeline connections are not presently available. In other cases, the gas is being used in pressure maintenance operations to produce associated oil. In the majority of these fields, however, the helium is in natural gas that has a low heating value and thus is not suitable for fuel. Fields in the first two groups will be put on production eventually, and the helium reserves moved to the depleting category. An example of this is the Lisbon Field in southeastern Utah.

Table 2. Depleting and nondepleting demonstrated helium reserves and resources. Volumes in Bcf at 14.65 psia and 60°F.

	Depleting	**Federal**	**Nondepleting**	**Federal**
Measured Reserves[1]	129	70	53	45
Indicated Reserves	23	0	28	11
Measured Marginal Reserves	3	1	2	1
Indicated Marginal Reserves	94	1	3	1
Measured Subeconomic	9	4	1	<1
Indicated Subeconomic	20	<1	0	0
Total	278	76	87	58

[1]Does not include 35 Bcf in storage, of which 31 Bcf is owned by the Federal Government.

The field had been under pressure maintenance and secondary recovery operations since 1969, when gas production operations began. In conjunction with the gas production, helium extraction capabilities were added and helium recovery began during 1994. As natural gas prices rise, some of the fields with low-heating value gas will initiate production. In 1986, one major field in this group, Riley Ridge in Sublette County, Wyoming, began production from the Madison Formation. This transferred approximately 71 Bcf of helium from the nondepleting to the depleting category of measured helium reserves.

The Mineral Lands Leasing Act of 1920 reserves the ownership of all helium in natural gas found on Federal lands to the Federal Government. In this report, the term "Federal lands" applies to those lands on which the Government owns the gas rights. Under these provisions, the United States is estimated to own 115 Bcf of helium found in measured helium reserves on Federal lands. The measured helium reserves are comprised of 70 Bcf of depleting and 45 Bcf of nondepleting reserves (see Table 2). The nondepleting reserves on Federal lands may serve as a backup to the helium stored by the Government and are an integral part of the Government's helium conservation efforts.

Measured Marginal Helium Reserves

The measured marginal helium reserves are approximately 5 Bcf. These marginal reserves are found in 9 gas-producing areas in 6 states (see Table 1). A portion of these marginal helium reserves are found in different geologic formations in fields also containing measured helium reserves or in proximity to these reserves. They are classified as marginal helium reserves because the size of the resource is small or the helium content is lean (see Appendix A).

Helium-rich gasfields account for about 3 Bcf of the measured marginal helium reserves. These resources are classified as marginal reserves because of their small size, generally less than 0.5 Bcf of helium. About 2 Bcf of helium is found in helium-lean gasfields. Almost all of this is in the Arkansas Valley area in the Arkoma Basin. The fields in this area are small and produce from various zones of Pennsylvanian age. Gas samples from various zones in many of these fields have been analyzed by the Bureau. These analyses show similar gas and helium contents with very little variation. Since the fields are in close proximity to each other and the gas is eventually gathered by only two major pipeline companies, the resources in the Arkansas Valley area have been combined and are considered marginal helium reserves; whereas, individually, they would be classified as subeconomic helium resources. The economics of extracting the helium from the Arkansas Valley area will be a function of helium prices and revenue derived from the extraction and sale of other constituents of the gas stream.

Measured Subeconomic Helium Resources

This category is made up of both helium-rich and helium-lean gasfields. Each helium-rich gasfield containing less than 150 MMcf of helium, and each helium-lean gasfield containing more than 150 MMcf and less than 1 Bcf of helium is included, with the exception of McElmo Dome in southwestern Colorado which contains 5 Bcf of helium. The measured subeconomic helium resources are estimated at approximately 10 Bcf. Nearly all of these resources are depleting and most are in helium-lean gasfields, with less than 0.5 Bcf in helium-rich gasfields. The helium resources are listed by state in Table 1. Although it is possible to extract helium from gasfields in this category, it is unlikely. These gasfields are isolated from current helium extraction facilities and contain small amounts of helium. The exception is the McElmo Dome Field. This field contains about 5 Bcf of helium in 6 Tcf of carbon dioxide gas. The gas is being produced for use in secondary recovery operations in Texas. The field is not classified as a marginal helium reserve because the helium content is only 0.07%, which would make extraction much more costly than extraction from other helium-lean fields with higher helium contents.

Indicated Helium Resources

The indicated helium resources of the United States are: (1) 51 Bcf of reserves, (2) 97 Bcf of marginal reserves, and (3) 20 Bcf in subeconomic resources. The indicated helium resources are derived from the PGC's estimate of probable resources of natural gas. The average helium contents are estimated for each PGC region or basin and used to determine the amount of indicated helium in each basin. See Figure 3 for a general map of PGC regions. The assumption is that probable gas resources in a basin will contain similar gases and helium contents as proven gas reserves. However, new discoveries may contain significant higher helium contents than previously found in a particular basin. In addition, some basins contain indicated helium that has been evaluated in conjunction with individual gasfield evaluations. This helium is included as part of the PGC-derived value, not added to it, except low-Btu gases that are not included in the PGC's estimate.

The indicated helium reserves contain 23 Bcf of depleting helium and 28 Bcf of nondepleting helium[6]. About 11 Bcf of this, all of which is nondepleting, is contained on Federal land. The indicated marginal helium reserves contain 94 Bcf of depleting helium and 3 Bcf of nondepleting helium. Only about 2 Bcf of this is known to be on Federal land. The indicated subeconomic resources are all in depleting reservoirs and less than 1 Bcf is known to be on Federal land.

Approximately 33 Bcf of the indicated helium is associated with individually evaluated gasfields. Of this, 28 Bcf is contained in helium reserves and 5 Bcf is contained in marginal

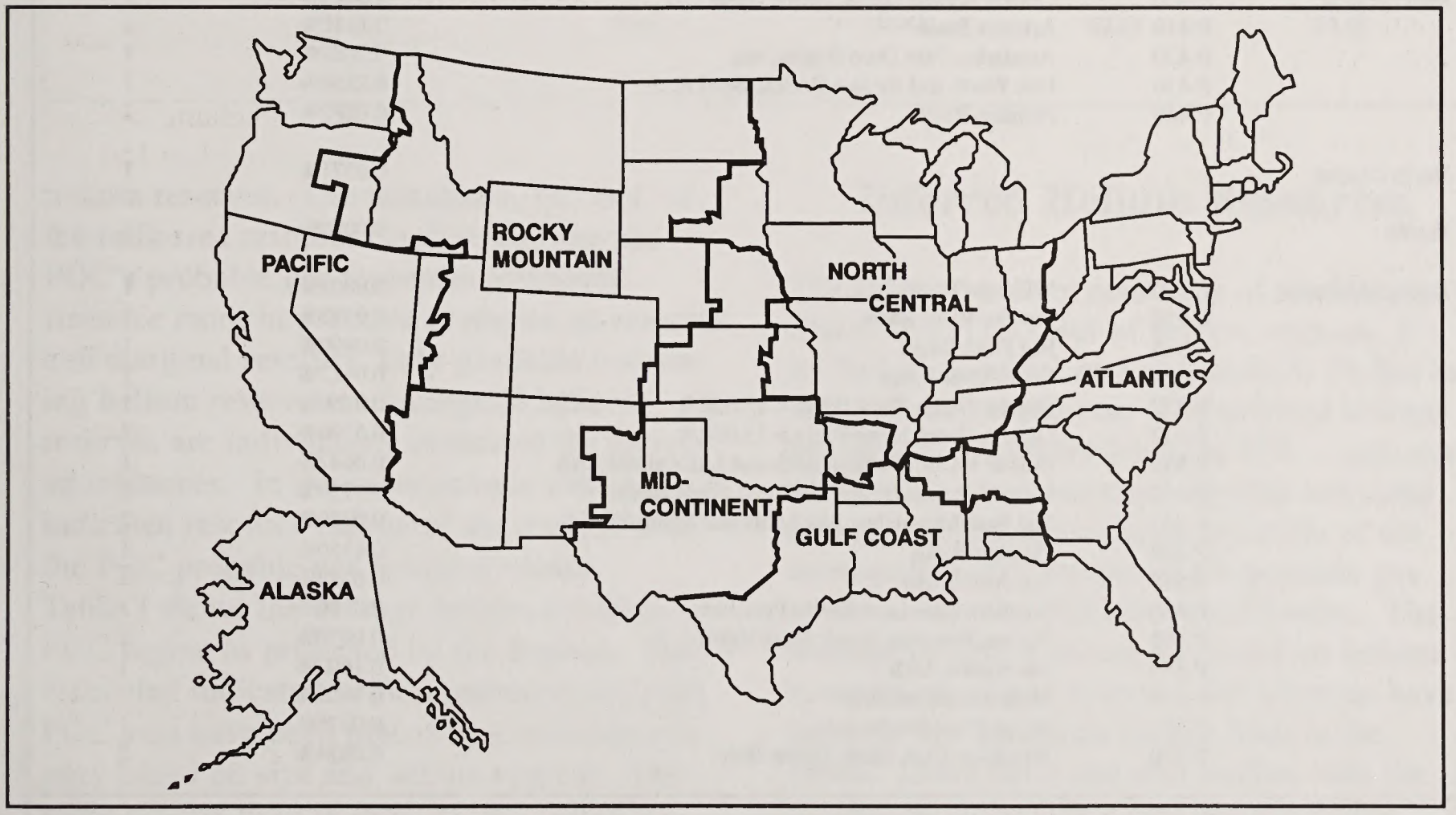

Figure 3. Map of potential gas committee regions.

[6] Technically, all indicated helium is nondepleting since these resources are not developed or actually producing. Terms "depleting" and "nondepleting" as used here show that the helium is associated with currently depleting or nondepleting fields.

Table 3. Estimated average helium contents of gas resources by PGC region and basin.

Region and Basin			Avg. Helium Content	Footnotes
Alaska			0.0111%	1
Atlantic:	P-100	New England and Adirondack Uplifts	0.0233%	1
	P-110	Atlantic Coastal Basin	0.0233%	1
	P-120	Appalachian Basin	0.0497%	1
	P-130	Piedmont-Blue Ridge Province	0.0497%	1
	P-140	South Georgia-Peninsular Florida	0.0150%	1
	P-150	Black Warrior Basin	0.0100%	1
Gulf Coast:	P-300	Louisiana-Mississippi-Alabama Salt Dome	0.0430%	1
	P-310	Louisiana Gulf Coast Basin	0.0020%	1
	P-320	East Texas Basin	0.0017%	1
	P-330	Texas Gulf Coast Basin	0.0020%	1
	P-930	Eastern Gulf Shelf	0.0014%	2
	P-931	Eastern Gulf Slope	0.0014%	1
	P-935	Louisiana Shelf	0.0014%	2
	P-936	Louisiana Slope	0.0014%	2
	P-940	Texas Shelf	0.0014%	2
	P-941	Texas Slope	0.0014%	2
	P-945	Gulf of Mexico Outer Continental Slope	0.0014%	1
Midcontinent:	P-400	Central Kansas Uplift, Salina Basin	0.2081%	1
	P-410	Arkoma Basin	0.0110%	1
	P-420	Anadarko, Palo Duro Basins, etc.	0.2081%	1
	P-430	Fort Worth and Strawn Basins, Bend Arch	0.2550%	1
	P-440	Permian Basin	0.0282%	1
North Central			0.0371%	1
Pacific			0.0069%	1
Rocky Mountain:	P-500	Williston Basin	0.0802%	1
	P-510	Powder River Basin	0.0793%	1
	P-515	Big Horn Basin	0.0490%	1
	P-520	Wind River Basin	0.0417%	1
	P-530	Greater Green River Basin < 15,000 ft	0.0760%	1
	P-530	Greater Green River Basin > 15,000 ft	0.5190%	3
	P-535	Denver Basin, Chadron Arch and Las Animas Arch	0.0642%	1
	P-540	Uinta/Piceance Basins; Park and Eagle Basins	0.1720%	1
	P-545	San Juan Mountains; San Louis and Raton Basins	0.0230%	2
	P-550	Paradox Basin	0.4150%	1
	P-555	San Juan Basin	0.0228%	1
	P-560	Southern Basin and Range Province	0.0150%	2
	P-565	Plateau Province, Black Mesa Basin	0.0070%	2
	P-570	Sweetgrass Arch	0.1602%	1
	P-575	Montana Folded Belt	0.1602%	1
	P-580	Snake River Basin	0.0275%	1
	P-590	Wyoming-Utah-Idaho Thrust Belt	0.0824%	2

FOOTNOTES:

1. The average helium content is weighted based on the number of gas samples from each formation and field combination in the region.

2. The average helium content is derived from pipeline gas surveys carried out by the Bureau and is weighted based on gas volumes flowing through gas plants in the region.

3. The average helium content is weighted heavily to the high helium-bearing gas in the Riley Ridge field. The helium contents of other gases in the area also are considered.

Table 4. Indicated helium resources by PGC basin. All volumes are in Bcf at 14.65 psia and 60°F.

PGC Basin		Reserves	Marginal Reserves	Subeconomic Resources
P-530	Greater Green River Basin >15,000'	21.78		
P-550	Paradox Basin	0.83		
P-400	Central Kansas Uplift, Salina Basin		0.73	
P-420	Anadarko, Palo Duro Basins, etc.		47.08	
P-430	Ft. Worth and Strawn Basins, Bend Arch		4.62	
P-540	Uinta, Piceance Basins		39.56	
P-570	Sweetgrass Arch		0.64	
P-120	Appalachian Basin			9.87
P-500	Williston Basin			0.49
P-510	Powder River Basin			1.32
P-515	Big Horn Basin			0.45
P-530	Greater Green River Basin<15,000'			5.94
P-535	Denver Basin, Chadron Arch			0.85
P-590	Wyoming-Utah-Idaho Thrust Belt			0.66
	Total	22.61	92.63	19.58

helium reserves. The remainder, 135 Bcf, of the indicated resources is derived from the PGC's probable gas resources estimates. Because more importance is placed on reserves and marginal reserves, only gasfields containing helium reserves and marginal helium reserves are individually evaluated for indicated resources. In the subeconomic category, all indicated resource estimates are derived from the PGC probable gas resource values. Table 3 shows the average helium contents by PGC region as projected by the Bureau. The estimated indicated helium resources for each PGC area have been placed in a resource category based on size and helium content. The same criteria used in determining resource placement for the measured reserves are applied to the indicated resources. These resource estimates are shown in Table 4.

Inferred Helium Resources

The inferred helium resources of the United States are: (1) 93 Bcf of helium reserves, (2) 64 Bcf of marginal reserves, and (3) 32 Bcf in subeconomic resources. The inferred helium resources are derived from the PGC's estimate of possible gas resources. As with indicated helium resources, estimates are made of the average helium contents of the possible gas resources for the PGC areas and basins. The average helium contents are based on helium contents of proven reserves and all areas have potential for significant helium finds in the future. Every basin and area studied, with the exceptions of the Gulf Coast and the Pacific areas, have contained some helium-rich natural gas. Possible Federal ownership of the inferred resources was not estimated.

Table 5 shows the estimated inferred helium resources for each PGC area and the category in which the resources are placed.

Where the average helium content of the PGC's possible gas resources is estimated to be less than 0.05%, the resources are placed in the subeconomic category rather than other occurrences as they are with probable resources. The reason for this is the probable resources are based on extension of productive fields and are more certain than the possible gas resources. The possible resources are a less assured supply because they are postulated to exist outside known fields, but are associated with a productive formation in a productive province. The possible resources were categorized and entered into the identified resources under the inferred resources of Figure1, and assigned to reserves, marginal reserves, and subeconomic resources. The PGC possible resources will be updated as more information becomes available on the area. For this reason, less reliance should be put on the helium resources of these areas until gas production is proven by development of new fields.

Table 5. Inferred helium resources by PGC basin. All volumes are in Bcf at 14.65 psia and 60°F.

PGC	Basin or Region	Reserves	Marginal Reserves	Subeconomic Resources
P-530	Greater Green River Basin>15,000'	88.53		
P-550	Paradox Basin	4.17		
P-400	Central Kansas Uplift, Salina Basin		0.21	
P-420	Anadarko, Palo Duro Basins, etc.		48.75	
P-430	Ft. Worth and Strawn Basins, Bend Arch		3.85	
P-540	Uinta, Piceance Basins		3.76	
P-570	Sweetgrass Arch		1.25	
P-575	Montana Folded Belt		6.44	
Alaska				1.83
P-120	Appalachian Basin			3.65
P-150	Black Warrior Basin			0.07
	Gulf Coast Region (on and offshore)			4.37
P-410	Arkoma Basin			0.17
P-440	Permian Basin			6.23
	North Central Region			1.86
	Pacific Region			0.69
P-500	Williston Basin			0.83
P-510	Powder River Basin			1.98
P-515	Big Horn Basin			0.57
P-520	Wind River Basin			3.21
P-530	Greater Green River Basin <15,000'			3.59
P-535	Denver Basin, Chadron Arch			0.78
P-545	San Juan Mtns, San Louis/Raton Basin			0.09
P-555	San Juan Basin			0.66
P-560	Southern Basin and Range Province			0.21
P-590	Wyoming-Utah-Idaho Thrust Belt			0.83
	Total	92.70	64.26	31.62

Other Helium Occurrences

Other occurrences of helium include helium contained in nonconventional natural gas and extremely lean (low-grade) helium occurrences. All proven reserves of natural gas that contain less than 0.05% helium are in this category. In addition, helium in coal-bed methane and some carbon dioxide occurrences are also included. The helium resources in other occurrences are about 52 Bcf.

An average helium content is applied to the DOE/EIA reserves of natural gas less the evaluated natural gasfields containing measured helium to arrive at a value for helium contained in the remaining gas reserves. The average helium contents are derived from the helium survey analyses of gas wells and the continuing survey of gas transmission pipelines and are weighted based on flow through the pipelines. The total helium in other occurrences from this source is about 28 Bcf.

Also part of the other occurrences of helium are the coal-bed methane resources and some carbon dioxide resources. Helium content data is available only for one large coal-bed methane area and one carbon dioxide gasfield. The coal-bed methane resources in the Black Warrior Basin in northwestern Alabama are estimated at about 15 to 20 Tcf. The Bureau has estimated that this methane contains about 6 Bcf of helium. There are other coal-bed methane areas being developed and the PGC is estimating natural gas resources for their regions. As more data becomes available on the coal-bed methane, it will be integrated into this study. The helium resources in the carbon dioxide gases of the Sheep Mountain area of Colorado are less than 1 Bcf. Other carbon dioxide producing fields have significant helium contents and are categorized as helium reserves (Riley Ridge Field) and subeconomic (McElmo Dome) as previously discussed.

Additionally, certain evaluated fields containing helium-lean natural gas are contained in this category. These fields generally contain small amounts of helium and are remote from major gas transmission lines. These miscellaneous fields contain about 4 Bcf of helium.

The last source of helium in this category is from certain estimates from the resource category designated as probable gas resources by the PGC (Table 4). Basins and areas that contain probable gas resources with average helium contents of less than 0.05% are also placed in the other occurrences category and contain approximately 14 Bcf of helium. Table 6 lists all estimates of helium in other occurrences.

Table 6. Helium in other occurrences. Volumes in Bcf at 14.65 psia and 60°F.

Category	Occurrence
Coal-bed methane	
Black Warrior Basin	5.82
CO2 Resources	
Colorado/New Mexico	0.90
DOE/EIA	27.71
Miscellaneous	4.08
From PGC-Probable:	
Alaska	3.44
P-150 Black Warrior Basin	0.05
Gulf Coast Region	2.94
P-410 Arkoma Basin	0.18
P-440 Permian Basin	2.38
North Central Region	1.13
Pacific Region	0.12
P-520 Wind River Basin	2.57
P-555 San Juan Basin	1.10
Total	52.42

Undiscovered Helium Resources

The undiscovered helium resources in the United States are estimated at a most likely value of 109 Bcf, with a minimum value of 44 Bcf and a maximum value of 258 Bcf. The estimates are based on the PGC's minimum most likely and maximum speculative gas resources combined with the Bureau's estimate of average helium contents. The same average helium contents that are used for indicated and inferred helium resources are used for undiscovered resources. No attempt was made to estimate the minimum and maximum helium contents because for most basins the helium contents fall within a very narrow range of values. For example, analyses of gases from the offshore Gulf Coast area have never indicated helium contents greater than 0.05%. In areas, such as the midcontinent, where the helium contents have a wider range of values, statistical analyses showed no pattern to the helium contents based on size of reservoir or discovery. The authors considered arriving at and applying a minimum and maximum helium content to the PGC's minimum and maximum gas resource values; however, after careful consideration, it was decided to use only the average values. The reason for this decision is one can argue that larger gas discoveries do not necessarily translate into greater helium contents for the gas. Further, studies of proven gas reserves by basin, reservoir, and helium contents(13) show that gases in most basins and reservoirs contain helium contents within a narrow range of values. Also, new discoveries within these basins tend to follow the helium content pattern of past discoveries.

Production and Extraction

Background

The Bureau's role in helium dates to World War I when the Army and Navy became interested in using helium as an inert lifting gas and contacted the Bureau for assistance because of its natural gas expertise. The Helium Act of 1925 officially placed the helium program under Bureau control. The Bureau built a large-scale helium extraction and purification facility and began operations in 1929. During World War II, demand increased significantly and four more small government plants were built.

Increased helium demand in the 1950s led to construction of the Keyes, Oklahoma, helium plant in 1959. Dwindling midcontinent natural gas supplies aroused concerns that no economic source of helium would exist by the turn of the century and led to the passage of amendments to the Helium Act of 1925. The Helium Act Amendments of 1960 provided for the conservation of helium for essential Government needs and also was intended to promote the development of a private helium industry. The Act directed the Secretary of the Interior to purchase and store helium for future use and to maintain helium production and purification plants and related helium storage, transmission, and shipping facilities.

Purchases for the conservation program were made from private companies which added crude helium extraction plants to existing gas processing facilities. The Bureau built a high-pressure pipeline to transport the helium from Bushton, Kansas, and intermediate points to the Bureau-owned Cliffside Gasfield for storage. In 1973, the contracts with private companies were canceled because of cutbacks in the space program and because the Secretary determined that the long-term needs of the Government were adequately fulfilled. In the mid-1970s, the Bureau began accepting privately-owned crude helium for storage at the Cliffside Gasfield. As of December 31, 1996, private industry has about 4.1 Bcf of helium stored at Cliffside.

Currently, the helium needs of Federal agencies are being met and there is adequate helium in storage. According to the Helium Privatization

Act of 1996, the Government's stored helium will start being sold on the open market beginning no later than January 1, 2005, on a straight-line basis through January 1, 2015. The Act also stipulates that the Government will retain 600 MMcf of the conservation helium. The entire Federal helium demand is now supplied by private suppliers using IKCHS contracts.

Helium Privatization Act of 1996

On October 9, 1996, the President signed the Helium Privatization Act of 1996 (Public Law 104-273). This legislation directed the Government to cease the production and sale of refined helium on April 9, 1998. Some of the key components of this legislation are as follows:

- Production and sales of Grade-A helium ceased on April 9, 1998, requiring Federal customers to purchase helium from private industry.

- The disposal of all helium production, refining, and sales-related assets not later than 24 months after the closure of the helium refinery.

- Sale of Federal reserves of crude helium in excess of 600 MMcf to begin no later than January 1, 2005, and continuing to January 1, 2015. This is to be done using a straight-line method. This is based on the legislation as passed in the Helium Privatization Act of 1996. Amendments may be suggested based on the Secretary of the Interior's consultation with private and Government personnel, and the report to be done by the National Academy of Sciences.

- Continue operation of the helium storage field and conservation pipeline for storage and distribution of crude helium. This to meet private industry and Government needs using IKCHS contracts with private suppliers.

- Continue the collection of helium royalty and fee sales for helium extracted from Federal lands.

- Conservation of helium.

Uses of Helium

Helium is chemically inert, which means that no other element will combine with helium at any temperature or pressure. Helium is the second lightest element, with hydrogen being the lightest. Helium liquifies at approximately -452°F, making it useful in cryogenics, the study of the behavior of matter and energy at temperatures below -270°F. The properties possessed by helium make it an element which can be used in a variety of applications.

Since helium will not burn or react with other substances, it is used to shield reactive metals, such as aluminum, from contamination by other elements during arc welding. The inert characteristics of helium keep it from reacting in the body, which allows it to be used in breathing mixtures supplied to some undersea explorers and operating-room patients. Helium is seven times lighter than air and nonexplosive, thus making it applicable as the lifting gas inside high-altitude weather and research balloons and lighter-than-air craft.

Helium is used to control atmospheric conditions in special chambers where silicon crystals used in electronic applications are grown. Also, the display case exhibiting the first and last pages of the Constitution of the United States uses helium as an atmosphere control. Helium's immunity to radioactivity led to its use as a heat transfer medium in gas-cooled nuclear power reactors. The molecular size of helium allows it to escape through the tiniest holes, which makes helium useful for detecting leaks during the manufacture of sealed fluid systems like those used in refrigerators and vacuum systems. The very low temperature

at which helium liquifies causes certain metals to become superconductors losing all resistance to the flow of electricity. This made possible the construction of powerful magnets that can be used to monitor physical and chemical conditions inside the human body, and to accelerate sub-atomic particles to velocities near the speed of light for experiments in high-energy physics.

The development of liquid-fueled rockets increased the uses for helium in space exploration and missile technology. The Atlas, Saturn V, and Space Shuttle have applied the technology developed for helium used in space travel. The fuel tanks of all these spacecraft are pressurized by helium to push the fuel into the pumps feeding the rocket engines and to provide pressure, enabling thin-walled tanks to resist collapse when empty. The Space Shuttle also uses helium in the orbital maneuvering system engines that enable the shuttle to change the shape and altitude of its orbit. Other evolving technologies that require the unique properties of helium are: (1) metastable helium for energy storage, which involves raising helium electrons to an excited energy state and then stabilizing the atom there; (2) fiber-optic production, where an ultrapure inert atmosphere is required; (3) helium ion tumor treatment, where large inert particles are required; (4) liquid helium-cooled superconducting microswitches, called Josephson junctions, which are much faster than conventional semiconductors and use less power; and (5) "aneutronic" nuclear fusion of deuterium and helium-3, which results in few or no neutrons. Figure 4 shows the uses of helium in 1996.

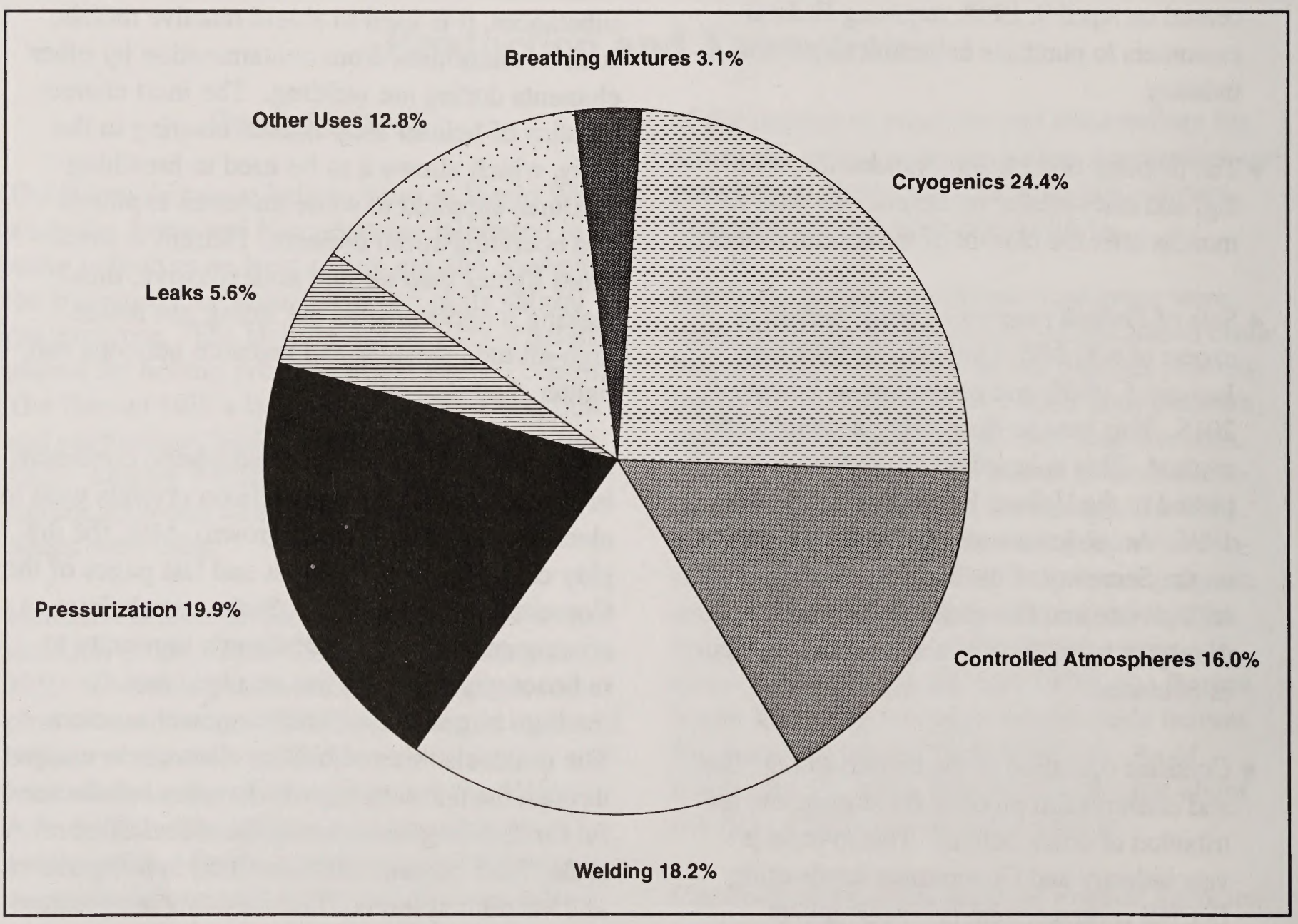

Figure 4. Uses of helium in 1996.

Supply and Demand

Historical production and extraction of helium in the United States is shown in Figure 5. The figure indicates a steady growth in helium recovered and sold since 1971, with greater percentage increases from 1986 to 1988, and smaller growth from 1988 to 1992. The domestic helium sales were affected by the Algerian helium plant coming online around 1994. This is where the figure shows a decline in sales. Market growth rate for domestic private industry helium has been flat at about 1% for the 5-year period 1992 through 1996, with exports falling by 17.7% from 1995 to 1996(14). The growth increased dramatically in late 1986 when Exxon Corporation began extraction of helium from Riley Ridge Field, Wyoming, at their Shute Creek plant. The plant extracts approximately 1 Bcf of pure helium per year, which is about plant capacity. Most of the growth in helium recovery since 1986 has been from the midcontinent area extraction plants. These plants sold about 900 MMcf of helium in 1987; in 1996, they sold about 2,200 MMcf of helium, which computes to an average annual growth of approximately 10%.

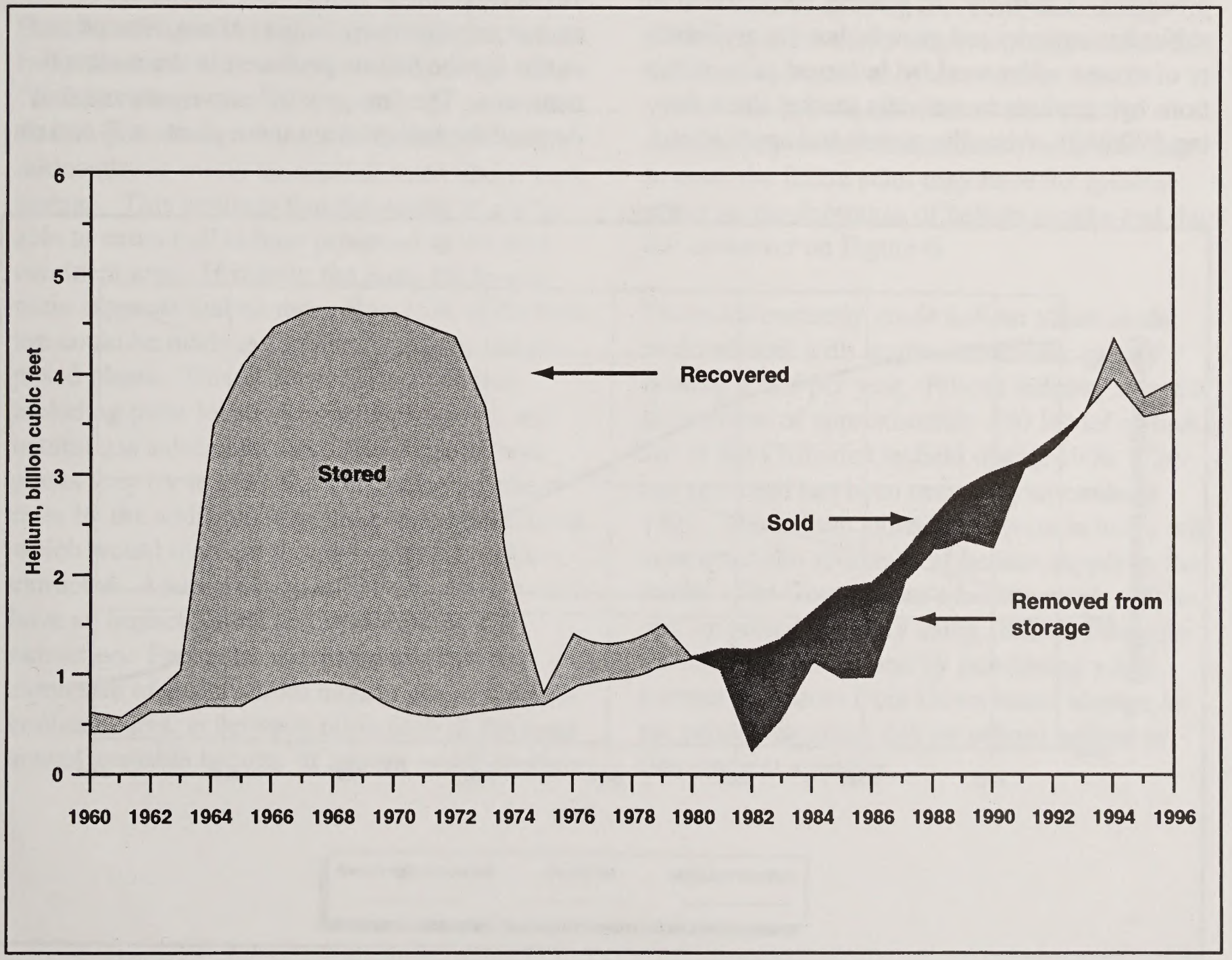

Figure 5. Production and extraction of helium in the United States.

Figure 6 shows the projected production and extraction of helium from the midcontinent area through the year 2012. Riley Ridge area helium production and extraction was not included in this projection because helium extraction at the Shute Creek plant is near capacity. Any significant growth in helium extraction from the area would require investment in another processing train. Since helium is only one of several products processed at the plant (the others are carbon dioxide, sulfur, and methane), the addition of a processing train would require some growth in demand for the other products. With the current low oil prices, an increased demand for carbon dioxide, which is used in secondary recovery processes, is unlikely. In general, the demand for sulfur has experienced growth, but the availability of excess sulfur worldwide forced price reductions by suppliers to maintain market share during 1996(15). Also, the permit and application process in this environmentally sensitive area is lengthy and sales of the products would have to be assured in advance. Any scenario for further development of Riley Ridge must take those factors into account.

The two sets of curves shown in Figure 6 are projected helium production and two helium sales growth curves. The helium production curve is based on projected deliverabilities of gas from the helium-rich natural gasfields in Kansas, Oklahoma, and Texas. These fields include Bradshaw, Greenwood, Kansas Hugoton, and Panoma Fields in Kansas; Guymon-Hugoton and Keyes in Oklahoma; and West Panhandle and Texas Hugoton in Texas. The second set of curves present two possible helium demand scenarios for the helium produced in the midcontinent area. The "no growth" curve assumes that demand for helium from these plants will remain

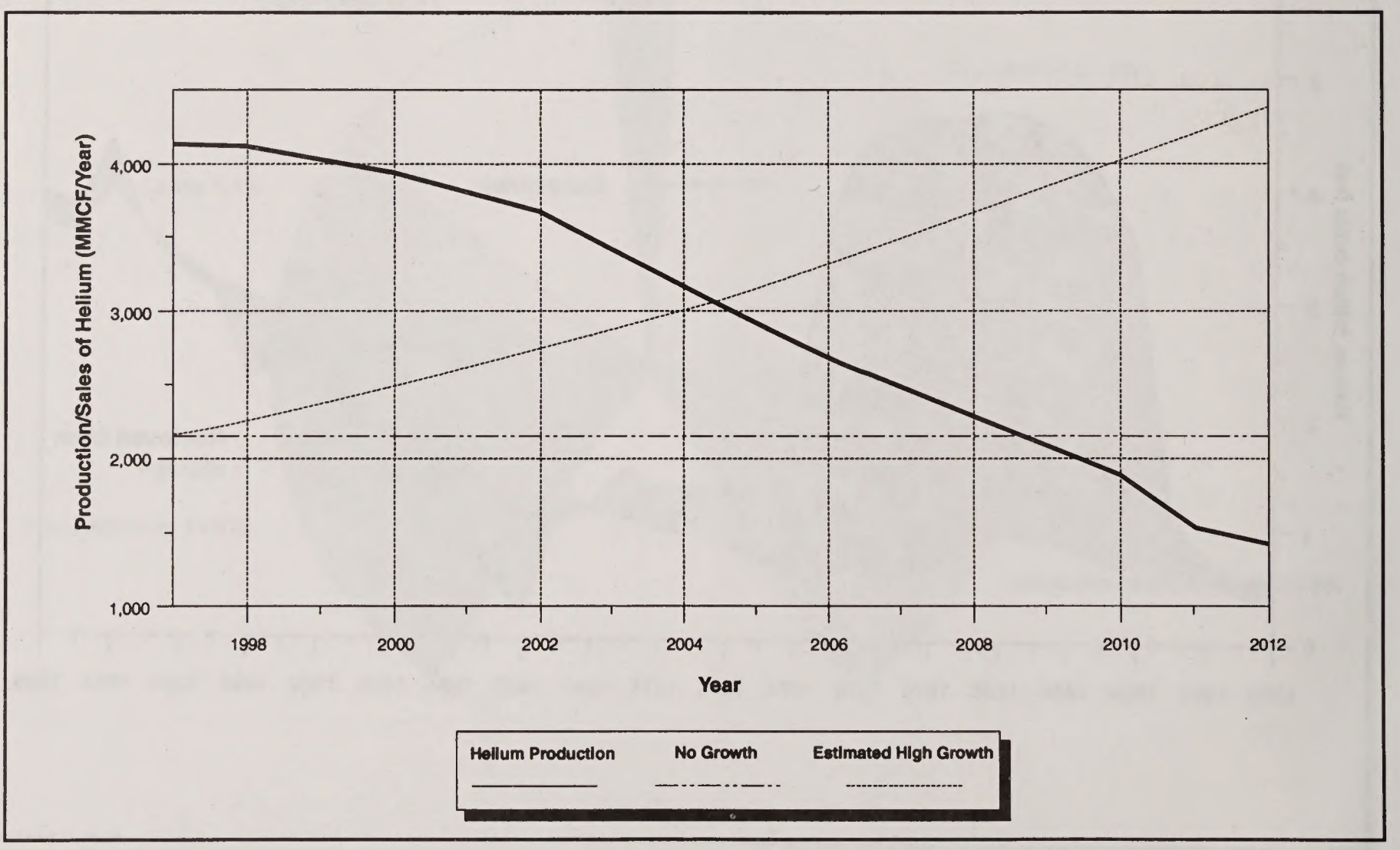

Figure 6. Supply and demand forecasts for helium from the midcontinent area.

steady and growth in sales will be taken up by a combination of new facilities in other areas, lower exports, and increased capacity at Riley Ridge. The "estimated high growth" curve assumes 4.8% annual growth in helium sales. This curve is based on the average domestic growth in helium sales from 1987 through 1996. The actual helium sales growth rate will vary from this percentage on a year-to-year basis, but this gives one possible scenario of future helium sales based on recent historical data. The possible decline of helium sales through technological advances or extraction of helium outside the United States may play a major role in the future of the helium industry.

Data from Figure 6 suggest that available helium from the midcontinent fields will intercept the "estimated high growth" curve by the year 2004. At that point, other sources of helium from the midcontinent would be needed, most likely from storage. This assumes that the plants would be able to extract all helium produced in the midcontinent area. However, the more likely scenario suggests that no more than 75% of the helium could be made available to existing and proposed plants. This is due to several factors, including plant location, pipeline location, and natural gas sales contracts. The crude helium plants may try to hold plant capacity at present rates by the addition of wells in the midcontinent, which would increase the percentage of helium extracted. Additional crude-helium plants would have an impact on the helium available for extraction. Presently, it is estimated that the extraction of helium from natural gas in the midcontinent area, is between 60 to 65% of the total annual available helium. If current trends continue and helium sales growth is approximately 4.8%, it is possible that shortages in the helium supply could occur starting in 2002. This is based on the current crude helium extraction capabilities of plants in the midcontinent area. This could be delayed by the addition of crude helium extraction plants in the midcontinent area. Also, the development of helium purification plants outside those existing in the midcontinent could help absorb the growth of helium sales. This could help the midcontinent producers to increase their helium storage at Cliffside Gasfield and may extend the time to expected shortages of helium supply. There is a possibility the helium production decline curve will not be as steep as projected due to infill drilling and other technology. However, a less steep slope may only increase the time to crossover by as much as 5 to 10 years. The growth of helium sales and the demand put on the midcontinent helium industry to meet the future sales may have the greatest effect on the shortages of helium supply and thus the crossover on Figure 6.

There are currently crude helium plants in the midcontinent with ample extraction capacity nearing 3 Bcf per year. Private industry stored a net amount of approximately 550 MMcf of helium in the Cliffside Gasfield during 1996. This storage trend has been occurring since about 1992. The helium stored by private industry will counteract the shortages of helium supply in the future. The Government's helium needs will be met by private industry using IKCHS contracts. Essentially, this is done by purchasing a like amount of helium from Government storage as the private suppliers deliver refined helium to Government agencies.

Summary

This report uses several criteria to determine reserves, marginal reserves, and subeconomic resources, including helium content, proximity to major gas transmission lines, and size of field. Refinements in evaluating other occurrences of helium and undiscovered resources also have been made for this report. In previous Bureau reports, it was concluded that relatively large volumes of helium would be available from natural gas through 2020, although that helium would probably be in gases with leaner concentrations than those being processed today. This report does not estimate nationwide projections for helium in natural gas production. Rather, the report focuses on short-term supply and demand for helium and examines the possible repercussions of a no growth and 4.8% growth of helium sales. These scenarios are used to project into the future for the occurrence of shortages of helium supply in the midcontinent area. The private industry plants in the midcontinent area have made great strides in the storage of helium since the 1992 publication of this report. Storage of helium was increased from approximately 2.0 to 4.1 Bcf for the period 1992 through 1996. This study suggests that in 5 to 10 years the process will have reversed to withdrawal of private storage from helium supply that will be available for extraction at that time.

As of December 31, 1996, there are 34.6 Bcf of helium stored in Bush Dome at Cliffside Gasfield. The Bureau owns 30.5 Bcf and 4.1 Bcf is owned by private companies. There are also approximately 3.7 Bcf of helium contained in the natural gas in Bush Dome. There is excess available helium in the present market place. This helium is being stored to meet future private demands and acts as a conservation effort for declining helium resources. The helium stored by the Government is set to be sold off starting no later than January 1, 2005, with proceeds used to pay the helium debt. This is in compliance with the Helium Privatization Act of 1996.

There are nondepleting helium resources throughout the United States that will act to conserve helium; however, several factors will need to be considered prior to production of this gas. Some of the factors are: 1) the location of the field(s), 2) the helium resources of the field(s), 3) the economics of helium extraction from the natural gas stream of the field(s), and 4) field(s) located on Federal lands may be restricted by regulations from processing the gas stream for the sole purpose of helium extraction.

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Glossary of Reserve and Resource Terms

The following definitions are based on definitions found in *Principles of a Resource/Reserve Classification of Minerals, Geological Survey Circular 831, 1980*, with additions and revisions where necessary to accommodate for helium.

Resource - A concentration of naturally occurring solid, liquid, or gaseous material in or on the earth's crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible.

Identified Resources - Resources whose location, grade, quality, and quantity are known or estimated from specific geologic evidence. Identified Resources include reserves, marginal reserves, and subeconomic resources components. To reflect varying degrees of geologic certainty, these economic divisions can be subdivided into *measured, indicated*, and *inferred.*[1]

Demonstrated - A term for the sum of measured and indicated.

Measured - The quantity is computed from dimensions revealed by actual gas analyses; production or formation tests, electric logs, and core analyses; and/or delineated by drilling and defined by fluid contacts or undrilled areas that can be reasonably judged as commercially productive on the basis of geologic and engineering data.

Indicated - Quantity and quality are computed from information similar to that used for measured resources, but the amounts are less certain and can be estimated with a degree of certainty sufficient to indicate they are more likely to be recovered than not. In general, they include reserves in formations that appear to be productive based on log characteristics but that lack core data or definitive tests, and reserves that will be found by field extensions, in-fill drilling, or improved recovery methods.

Inferred - Estimates are based on an assumed continuity beyond measured and/or indicated resources, for which there is geologic evidence. *Inferred resources* may or may not be supported by analyses or measurements.

Reserve Base - That part of an identified resource that meets specified minimum physical and chemical criteria related to current drilling and production practices, including those for quality, porosity, permeability, thickness, and depth. The *reserve base* is the in-place demonstrated resource from which reserves are estimated. It may encompass those parts of the resources that have a reasonable potential for becoming economically available within planning horizons beyond those that assume proven technology and current economics. The reserve base includes those resources that

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[1]The terms "proved," "probable," and "possible," which are commonly used by industry in economic evaluations of ore or mineral fuels in specific deposits, reservoirs, or districts, have been loosely interchanged with the terms *measured, indicated*, and *inferred.* The former terms are not a part of this classification system.

are currently considered reserves, marginal reserves, and some of those considered subeconomic resources. For helium, the measured portion of subeconomic resources is included in the reserve base but not the indicated portion.

Inferred Reserve Base - The in-place part of an identified resource from which inferred reserves, marginal reserves, and subeconomic resources are estimated. Quantitative estimates are based largely on knowledge of the geologic character of a reservoir and for which there may be no gas analyses or measurements.

Reserves - That part of the reserve base which could be economically extracted or produced at the time of determination. The term *reserves* need not signify that extraction facilities are in place and operative. *Reserves* include only recoverable materials; thus, terms such as "extractable reserves" and "recoverable reserves" are redundant and are not a part of this classification system.

Marginal Reserves - That part of the reserve base which, at the time of determination, borders on being economically producible. Its essential characteristic is economic uncertainty. Included are resources that would be producible, given postulated changes in economic or technologic factors.

Subeconomic Resources - The part of identified resources that does not meet the economic criteria of reserves and marginal reserves.

Other Occurrences - Resources which are contained in extremely low-helium content natural gases or nonconventional natural gas reserves. Only "proved" and "probable" natural gas reserves of this type are evaluated and included in the classification.

Undiscovered Resources - Resources, the existence of which are only postulated, comprising deposits that are separate from identified resources. The *undiscovered resources* of helium are postulated based on the "speculative" resources reported by the PGC.

APPENDIX A
Guidelines for Determining Helium Reserves and Resources

The following guidelines apply for determining helium reserves, marginal helium reserves, and subeconomic helium resources as contained in this publication. The guidelines also are helpful for determining undiscovered resources.

Individual Field Reserves and Resources

Helium Content %	Contained Helium in Field/Area	Category
≥ 2.00	≥ 150 MMcf	Reserves
0.30 - 2.00	≥ 1 Bcf	Reserves
≥ 0.30	150 MMcf - 1 Bcf	Marginal Reserves
≥ 0.30	10 - 150 MMcf	Subeconomic Resources
0.10 - 0.30	≥ 5 Bcf	Reserves
0.10 - 0.30	1 - 5 Bcf	Marginal Reserves
0.10 - 0.30	150 MMcf - 1 Bcf	Subeconomic Resources
0.10 - 0.30	10 - 150 MMcf	Other Occurrences
0.05 - 0.10	≥ 5 Bcf	Subeconomic Resources
0.05 - 0.10	10 MMcf - 5 Bcf	Other Occurrences
< 0.05	Large coal-bed methane or corbondioxide resources- >5 Bcf cont. helium	Other Occurrences

The previous guidelines also apply for area-wide classifications. In addition, the following guidelines are applied to basinwide resources. An average helium content is used for each basin and the reserves/resources determined by applying the average helium content to the basin's gas resource estimate for probable and possible categories. For the undiscovered resources, the average helium content is applied to minimum, most likely, and maximum speculative PGC gas resource numbers.

Area-Wide Classifications

<0.05	All DOE/EIA reserves after subtracting computerized data base measured reserves	Other Occurrences
<0.05	PGC probable gas resources in a basin or region	Other Occurrences
<0.05	PGC possible gas resources in a basin or region	Subeconomic Resources

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13. ABSTRACT *(Maximum 200 words)*

The identified helium resources of the United States are estimated at 589 Bcf, as of December 31, 1996. This includes 268 Bcf of demonstrated reserves, 102 Bcf of demonstrated marginal reserves, and 30 Bcf of demonstrated subeconomic resources. The identified resources also include 157 Bcf of helium in inferred reserves and inferred marginal reserves and 32 Bcf in inferred subeconomic resources. The demonstrated helium resources contained on Federal lands are approximately 165 Bcf, including 31 Bcf in underground storage in the Cliffside Gasfield near Amarillo, Texas. In addition to the identified helium resources, undiscovered helium resources in the United States are estimated at a most likely volume of 109 Bcf, with a maximum volume of 258 Bcf and a minimum volume of 44 Bcf. Also reported are 52 Bcf of helium in nonconventional and low helium content natural gases.

Current extraction of helium in the United States occurs mostly from natural gases produced from the Hugoton gas area in Kansas, Oklahoma, and Texas, and the Riley Ridge area in southwestern Wyoming. Helium extracted from natural gas in the United States in 1996 was approximately 3.8 Bcf. The addition of crude helium plants in the midcontinent area since the last report has increased the volume of helium available for storage by private industry. However, the volume of helium produced with the natural gas in the Hugoton gas area continues to decline. The current trend is storage by private industry at the Cliffside Gasfield, and the shortfall of helium supply will reverse this trend to withdrawal of helium. If the current trends continue, a shortage of helium supply could occur in about 5 to 10 years.

14. SUBJECT TERMS

helium resources
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demonstrated marginal reserves
undiscovered helium resources
demonstratrated subeconomic resources
crude helium plants
inferred reserves
inferred marginal reserves
inferred subeconomic resources

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